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GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES I AND II

W. Dyck and J. G. Fyles

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CANADA

This paper reports ages determined in the C^{14} Dating Laboratory of the Geological Survey between January 1961, when the laboratory commenced operations, and November 1962. This issue is reprinted directly from "Radiocarbon", Part I from Vol. 4, 1962, pp. 13-26, Part II from Vol. 5, 1963, pp. 39-55, and marks the beginning of an annual series.

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES I

W. DYCK and J. G. FYLES

INTRODUCTION

This paper reports the first ages determined in the C^{14} Dating Laboratory of the Geological Survey of Canada. The C^{14} dating program of the Geological Survey is a cooperative project; geologists of the Pleistocene Section assess and select samples for dating, and the Isotope and Nuclear Research Section, under Dr. R. K. Wanless, developed and operates the laboratory and calculates ages. The first part of this paper, devoted to sample preparation, counting procedure, and interlaboratory check dates was prepared by the first author, who built and operates the laboratory. The date list was compiled by the second author from descriptions of samples and interpretations of dates provided by various collectors. Most samples analyzed so far have originated within the Geological Survey.

Preparations for the development of a C^{14} laboratory within the Department of Mines and Technical Surveys, Ottawa, were begun by Dr. C. Lapointe, Nuclear Radiation Section, Mines Branch. At an early stage the project was turned over to the Geological Survey and active construction of the present laboratory was begun during 1959. By early 1961 one proportional-counting tube with highly satisfactory counting characteristics was in operation and systematic dating commenced. The age determinations reported here were completed from January to November 1961.

ACKNOWLEDGMENTS

Acknowledgement is made to Dr. W. J. Broecker of the Lamont Geological Observatory for suggestions regarding some facets of the laboratory development, and to Dr. K. J. McCallum, Department of Chemistry, University of Saskatchewan, for providing the samples used for the check dates GSC-20 and 21. The proportional-counting tubes were fabricated by A. G. Meilleur, Superintendent of the Geological Survey Research and Development Shop.

APPARATUS AND PROCEDURE

Sample Preparation

All organic samples, unless noted otherwise, were treated with hot 4% NaOH, hot 2N HCl, and washed with hot water.

Samples were burned in a stream of oxygen and the released CO_2 purified by passage through the following chemicals and traps: hot CuO, dil. H_2SO_4, 0.1 N AgNO3, H_2SO_4-CrO_3 sol'n, drierite, an acetone-dry ice trap, hot Pt-asbestos, and hot Ag-wool. Radon was separated from CO_2 by fractional distillation as described by de Vries (de Vries, 1957). Final purification of CO_2 was achieved by passage through $Mg(C10_4)_2$ and hot, freshly regenerated copper.

Shells were cleaned with a stiff brush and water before and after removal of 10% of outer layers with HCl. CO_2 was liberated with H_3PO_4.

Counting Apparatus

The counting apparatus is situated in the sub-basement of the eight story Geological Survey building.

Samples were counted in a 2 L copper, proportional counter. The end plates and quartz insulators were glued in place with araldite. This counter is operated within a shield comprised of 8 in. of cast iron, 4 in. of paraffin, 21 G.M. tubes and a stainless steel vessel providing a 1 in. layer of Hg.

When filled with CO_2 to a pressure of 150 cm of mercury a background count of 1.5 counts/min and a net modern-wood count of 20.2 counts/min were recorded.

Experiments with several counters suggest the low background was obtained by machining the inside surface of the counter tube.

Counting Procedure

With a few exceptions the counter was operated at two atmospheres. During the first eight months of operation one background and one modern wood count were made each week and each unknown sample was counted at least twice for 20 hrs. Recently a less rigorous counting procedure was introduced as follows: background, two unknowns, modern wood, two unknowns, background. Unknowns counted over a weekend, unless very old, were not counted twice.

A new background and standard gas were prepared every six weeks. Each counter filling was checked with an external pitchblende source before and after the counting period in order to detect possible shifts in the operating voltage. Variations of up to 15 v were observed between different counter fillings, suggesting small differences in the concentration of electronegative impurities in the sample gases. A similar shift was observed after a gas was used four or five times.

Calculations and Errors

Ayll ages reported were calculated using the corrected activity of 105 yr old Douglas Fir wood from Vancouver Island as the reference standard. Two gas preparations of NBS oxalic-acid standard compared to two of the Douglas Fir wood gas preparations gave the following relationship:

$$0.945\ A' = A$$

where A′ is the counting rate of the oxalic-acid gas and A the counting rate of the wood corrected to zero age.

The value of 5568 ± 30 yr for the half life of C^{14} was used in these calculations.

Upper age limits were calculated from values obtained by adding four standard deviations to statistically insignificant counting rates.

No corrections for possible isotopic fractionation were applied. Although the C^{13}/C^{12} ratio for shells and terrestrial plants is different, ocean mixing rates are apparently such that the corresponding difference in the C^{14}/C^{12} ratio is not observed for shallow-water sea shells (Craig, 1954). Hence the

same standard was used for all samples. Close agreement between GSC-24 and GCS-38 lends support to this argument.

Errors reported were based on statistical variations observed. Counts outside the probability range, as predicted from the randomness of radioactive decay, were discarded; *i.e.* if one of three counts was more than two standard deviations away from the average. During the past 11 months six such anomalous counts were recorded.

Results of Check Samples

Determinations of ages of check samples listed in Table 1 were carried out over a period of eight months.

Satisfactory agreement between the ages determined in this laboratory and those from other laboratories is evident. However, slight trends appear to be present; three of the four Isotopes Inc. ages are older than the GSC ages, while all three Lamont ages are slightly younger.

TABLE 1

Comparison of ages of identical sample fractions dated by various laboratories

GSC Laboratory		Other Laboratories			
Sample No.	Age (yr)	Sample No.	Age (yr)	Reference RADIOCARBON	Sample Material
GSC-1	12,400±200	L-391 D	12,150±250	Lamont V	wood
			12,000±450	Isotopes I	
GSC-2	7600±150	S-99	7300±120	Saskatchewan III	detrital peat
GSC-4	10,190±120	I(GSC)-185	10,600±320	Isotopes II	peat
GSC-5	10,140±160	I(GSC)-2	10,220±350	Isotopes I	wood
GSC-13	29,500±800	L-424C	29,300±1400	Lamont V	wood
GSC-14	26,000±600	L221A	25,900±300	Lamont V	wood
GSC-20	4275±100	S-25	4600±210	Saskatchewan II	wood
GSC-21	10,400±140	S-81	10,200±250	unpublished	wood
GSC-37	12,600±170	I(GSC)-248	12,800±175	Isotopes II	marine shells

The peat sample GSC-4 was dated three times and a summary of the sample treatment and results is shown in Table 2.

TABLE 2

Summary of treatment and results of sample GSC-4

Sample preparation	No. of counts	Chemical treatment	Age
1	2	40% of sample treated with NaOH Total sample treated with HCl	10,100±200
2	1	Total sample treated with base and acid	10,050±140
3	2	No chemical pretreatment	10,410±150

Although the age appears to decrease with increasing chemical pretreatment, the variation is not significant in view of the errors of the ages. The first count of the second preparation gave an age of 9860 ± 160 yr but was

omitted because of the presence of some radon in the sample. Also the first count of the third preparation was omitted. Although no radon was detected in this preparation the counting rate was more than two standard deviations above average.

Sample GSC-5 was counted once at a reduced pressure of 147 cm and once mixed with 24.4% coal gas. The counts gave the ages 10,200 ± 190 yr and 10,090 ± 130 yr respectively.

Sample GSC-21 and its unpublished Saskatchewan date were provided by Dr. K. J. McCallum. As indicated in a letter from Dr. McCallum (November 28, 1961), this sample is from the Scrimbit site, Saskatchewan (49° 46′ N Lat, 105° 11′ W Long). The wood is from a depth of 15 ft above till, and was taken from a large root of a stump nearly 4 ft high, which appeared to be preserved in its original upright position. Dating of a series of samples from this site is being undertaken in the Saskatchewan Laboratory.

SAMPLE DESCRIPTIONS (GEOLOGICAL SAMPLES)

SOUTHERN CANADA

Arranged East to West

GSC-11. Clarenville, Newfoundland **3610 ± 100**

Peat from the bottom of a bog deposit at the head of SW arm of Random Sound, 10 mi S of Clarenville, Newfoundland (48° 02′ N Lat, 53° 48′ W Long). Sample collected with Hiller peat sampler 10 ft below bog surface at the contact of peat with underlying outwash gravel at alt 46 ft. The outwash is graded to a former sealevel at alt 35 to 40 ft. Coll. 1960 by E. P. Henderson, Geol. Survey of Canada, Ottawa. *Comment*: sample was dated to obtain a minimum age for the outwash; it is considerably younger than anticipated. In view of the much greater age of bog-bottom samples from the Avalon Peninsula to the SW (L-391I, 7400 ± 150, Lamont V; I(GSC)-4, 8420 ± 300, Isotopes I), the dated peat must be considerably younger than the underlying outwash. NaOH-leach was omitted from pretreatment.

GSC-18. Siegas, New Brunswick **9820 ± 130**

Wood from an organic layer, containing moss and fresh-water mollusc shells, lying within gravel 18 ft below ground on W bank of Siegas River 0.3 mi from its junction with St. John River, New Brunswick (47° 13′ N Lat, 67° 58′ W Long). Approximately 10 ft of Lake Madawaska clay overlies the gravel enclosing the dated layer. Coll. 1956 by H. A. Lee, Geol. Survey of Canada. *Comment*: sample is believed equivalent to I(GSC)-2, 10,220 ± 350 (Isotopes I), and provides a minimum date for the Grand Falls drift (Lee, 1955). Organic material from the stratigraphically higher Lake Madawaska sediments at two localities nearby has ages of 8200 ± 300 (L-190B, Lamont II) and 8250 ± 200 (W-353, USGS IV).

GSC-8. Northfield, Ontario **9430 ± 140**

Peat and gyttja overlying Champlain Sea sand and gravel 1.3 mi NW of Northfield, Ontario (45° 08′ N Lat, 74° 56′ W Long). Composite Hiller

sample from base of bog deposits 475 to 485 cm below ground. Site is at alt ca. 325 ft, ca. that of a pause in recession of the Champlain Sea, indicated by widespread dunes in the adjoining Prescott area (Terasmae and Mott, 1959). Coll. 1959 by Jaan Terasmae, Geol. Survey of Canada. *Comment*: on the basis of pollen studies, the base of this bog section (corresponding to GSC-8) is ca. equivalent to the bottom of the St. Germain bog profile (Terasmae, 1960) dated as 9500 ± 300 (L-441C, Lamont VII). The date also provides a minimum age for the 325-ft stand of the Champlain Sea. Marine shell samples inferred to represent ca. the same phase in the history of marine submergence of the surrounding region have C^{14} dates averaging ca. 10,500 yr (Sample 10 mi E of Northfield site: L-604C, 10,600 ± 200, unpub. Samples from Ottawa: Y-216, Yale II; L-604A, L-604B, Lamont VII: L-604D, 10,200 ± 200, unpub.). NaOH-leach was omitted from sample pretreatment.

GSC-26. Rouge River, Ontario **2400 ± 75**

Gyttja from stream-terrace sand and gravel 2 mi ENE of Brown's Corners, Scarborough Township, Ontario (43° 49′ N Lat, 79° 12′ W Long). Sample from bank of Rouge River 22 ft above stream and 5 ft below terrace surface. Coll. 1960 by P. F. Karrow, Ontario Dept. Mines and Jaan Terasmae. *Comment*: terrace and gyttja are younger than Lake Iroquois and relate to development of the valley of Rouge River after establishment of the present level of Lake Ontario. Pollen studies of terrace deposits along the river are in progress. NaOH-leach was omitted from sample pretreatment.

GSC-15. New Liskeard, Ontario **5780 ± 100**

Peat and gyttja from base of a bog overlying Glacial Lake Barlow-Ojibway sediments 9 mi NNW of New Liskeard at Maybrook Station, Ontario (47° 37′ 03″ N Lat, 79° 45′ 20″ W Long). Sample coll. 1960 by Jaan Terasmae with Hiller peat sampler 300 to 310 cm below bog surface. *Comment*: date is minimum for drainage of Glacial Lake Barlow-Ojibway to below the alt of the Little Clay Belt. Pollen studies indicate that the lower, dated part of the bog profile records warmer and perhaps dryer conditions than the upper four-fifths of the profile. NaOH-leach was omitted from pretreatment of sample.

GSC-6. Underwood, Ontario **600 ± 70**

Wood enclosed in sand and gravel at foot of Lake Algonquin wave-cut cliff 3.2 mi NW of Underwood, SW Ontario (44° 19′ N Lat, 81° 33′ W Long). Sample from 3 or 4 ft below ground on the cut-bank of a small stream at alt 650 ft. Coll. 1960 by Jaan Terasmae. *Comment*: wood and enclosing sand and gravel were inferred to have been deposited along the shore of Lake Algonquin. In view of the date, however, these deposits are of much younger age, and must therefore be alluvium of the adjoining small intermittent stream. NaOH-leach was omitted from pretreatment of sample.

GSC-7. Little Long Rapids, Ontario **6910 ± 120**

Wood at base of bog deposit, ca. 5 ft thick, 3 mi S of Smoky Falls on Mattagami River, Ontario (50° N Lat, 82° 12′ W Long). Peat section, exposed during excavations at a dam site, is underlain by clay and sand lying upon

bedrock. Site is higher than marine limit in James Bay Lowland. Coll. 1960 by Jaan Terasmae. *Comment*: site lies inside the limit of the Cochrane readvance, thus the date is minimum for that event.

GSC-31. Attawapiskat River, Ontario **5670 ± 110**

Peat from bog deposit exposed in bank of Attawapiskat River 4 mi above Muketei River, James Bay Lowland, Ontario (53° 07′ N Lat, 85° 25′ W Long). Sample is from bottom few inches of peat section, 6.5 ft thick, overlying clay-rich till at alt ca. 460 ft. It is less than 50 ft below the uppermost postglacial marine level (unpub. commun. from V. K. Prest). Coll. 1957 by H. Sjors; subm. by Jaan Terasmae. *Comment*: marine shells collected close to the marine limit in the James Bay area exceed 7000 yr in age (I(GSC)-14, 7875 ± 200, Isotopes I; Gro 1698, 7280 ± 80, Terasmae and Hughes, 1960). Hence development of the bog profile at this site (Sjors, 1959) began considerably after the initial influx of the sea. NaOH-leach omitted in pretreatment of this sample.

GSC-9. Nungesser Lake, NW Ontario **8860 ± 250**

Gyttja from kettle in NE part of basin of glacial Lake Agassiz, within 100 yd of W end of Nungesser Lake, Ontario (51° 26′ N Lat, 93° 43′ W Long). Composite Hiller sample from basal 2 in. of a bog section consisting of 14 ft of peat underlain by 1 ft of gyttja. The bog sediments overlie sand, but in the lowland to the W peat up to 15-ft thick overlie glacio-lacustrine clayey silt. Bog development in the kettle probably began soon after falling Lake Agassiz water uncovered the kettle rim, ca. 215 ft below the highest stand of the lake as recorded on the Trout Lake moraine 20 mi SE. Decrease in spruce and increase in pine in the lower part of the pollen diagram of the peat sequence in the kettle (unpub. commun. from Jaan Terasmae) indicates climatic amelioration early in the history of the bog. Coll. 1960 by V. K. Prest, Geol. Survey of Canada. *Comment*: age of this sample agrees with other dates and current ideas connected with deglaciation of northern Ontario, and supports the inference that the climatic amelioration recorded in the pollen profile corresponds to the beginning of the Hypsithermal interval. NaOH-leach was omitted in pretreatment of sample.

GSC-3. Taber Provincial Park, Alberta **10,500 ± 200**

Willow wood from sandy alluvium on the face of a strip coal mine adjacent to Oldman River just S of Taber Park, Alberta, in Sec. 12, T 10, R 17, W 4th Meridian (49° 48′ 30″ N Lat, 112° 10′ 30″ W Long). Sample from a buried sandy soil containing sticks and erect stumps of willow up to 6 in. in diam. Soil is overlain by 27 ft of sand (up to the prairie surface) and is underlain by 9 ft of silt and sand separated from bedrock by a few inches of gravel. The site lies within a small channel, eroded by Oldman River during early development of its postglacial valley and subsequently filled with alluvium. Coll. 1960 by A. M. Stalker, Geol. Survey of Canada. *Comment*: wood from same site, coll. by L. A. Bayrock, Research Council of Alberta, has been dated 11,000 ± 250 (S-68, Saskatchewan II).

Puntledge River series, Vancouver Island

Wood and marine shells from excavation beside penstock above Puntledge River Hydro-electric Station, near Courtenay, British Columbia (49° 41′ N Lat, 125° 02′ W Long). Samples from the bottomset part of a marine delta with top at alt 175 ft, ca. 375 ft below marine limit in the vicinity. Coll. 1956 by J. G. Fyles.

GSC-24. Puntledge River **12,200 ± 160**

Wood from a 2-ft layer of horizontally stratified silt and fine sand overlying pebbly marine clay and overlain by 10 ft of deltaic gravel.

GSC-38. Puntledge River **12,360 ± 140**

Marine pelecypod shells from same bed as GSC-24 and from uppermost few inches of the underlying clay.

General comment: close agreement between these two dates supports the reliability of dates on marine shells. The difference in age between these samples and a shell sample collected near the marine limit (I(GSC)-9, 12,500 ± 450, Isotopes I) is smaller than anticipated. As I(GSC)-9 is based upon an exceedingly small collection of tiny shell fragments from a site partly covered with modern pond algae, it appears to be less reliable than the dates reported here, and may be only minimum for the marine limit. See also L-391D, L-391E, L-391F, and L-441B (Lamont V).

Campbell River series, Vancouver Island

Various sub-till nonglacial plant-bearing deposits on Vancouver Island, near NW end of Strait of Georgia, differ in one way or another from the widespread interstadial Quadra sediments (Fyles, in press). Geologic considerations have failed to indicate whether these materials are younger or older than the Quadra or equivalent to it. The following dates apply to two (of the many) occurrences of such materials.

GSC-30. Salmon River **>40,000**

Wood from borrow pit beside highway, S side of Salmon River Valley, 10 mi upstream from Sayward, Vancouver Island, British Columbia (50° 15′ N Lat, 125° 48′ W Long). Sample from a 6-ft exposure of stony silt containing irregular lenses of peaty soil and fragments of wood. Silt is overlain by lenses of till 2-ft thick, capped by 9 ft of gravel and 3 ft of silty colluvium. Sub-till silt, perched on the bedrock wall of the U-shaped valley, appears to be a remnant of formerly much more extensive deposits that has fortuitously survived glaciation. Coll. 1950 by J. G. Fyles.

GSC-52. Campbell River **>37,200**

Wood from sub-till stream deposits in an excavation behind John Hart Hydro-electric Station, Campbell River, British Columbia (50° 07′ 40″ N Lat, 125° 18′ 30″ W Long). Sample from 10 ft above the base of ca. 85 ft of horizontally stratified grit, sand and silt resting on laminated marine silty clay and overlain by till and deltaic deposits. Coll. 1958 by J. G. Fyles.

General comment: dates are older than those yielded by plant materials from comparable parts of the Quadra sediments (range: 24,000 to 36,000; L-221A, L-221B, L-424B, L-424C, L-424E, Lamont V; L-502, Lamont VII). Nonetheless, as marine shells from the basal part of the Quadra have infinite dates (L-475A, L-475B, Lamont VII), there is no assurance that the deposits in question represent a nonglacial interval or intervals older than and separate from the Quadra interstadial. See also I(GSC)-5, >35,000 (Isotopes I).

NORTHERN CANADA I

General

GSC-50. North Fork Pass, Yukon **7510 ± 100**

Gyttja from lowermost 2 in. of a bog deposit occupying a depression in an arcuate terminal moraine in North Fork Pass at head of North Klondike River, Ogilvie Mountains, Yukon Territory (64° 34′ N Lat, 138° 15′ W Long). Sample collected with a ship's auger 5 ft below ground. The moraine marks the limit of the restricted latest advance of valley glaciers in the region, separated from an earlier more extensive glaciation by a considerable interval of erosion. Coll. 1961 by O. L. Hughes. *Comment*: date is minimum for the late advance of valley glaciers and admits, but does not demand, correlation of this advance with Riley Creek glaciation of Nenana Valley, Alaska, considered by Wahrhaftig (1958, p. 18) to have reached a maximum ca. 11,000 yr ago on the basis of W-49 (10,560 ± 200, USGS I). NaOH-leach was omitted from pretreatment of sample. Date based on one weekend count only.

GSC-29. Inuvik, Northwest Territories **>39,000**

Wood from sand and gravel, containing much ground ice, ca. 30 ft below the original surface, in gravel pit ca. 1 mi E of Inuvik, District of Mackenzie (68° 21′ 20″ N Lat, 133° 41′ 10″ W Long). Site lies within the area of a delta-kame complex at the mouth of an abandoned channel apparently eroded by a W-flowing stream during the last deglaciation of the region. Coll. 1960 by J. Ross Mackay, Univ. of British Columbia; subm. by the Geog. Branch, Dept. Mines and Tech. Surveys, Ottawa, Canada. *Comment*: sample was dated to gain information about the age of retreat of the last (late Pleistocene, probably classical Wisconsin) ice sheet from the area. In view of the infinite date, the wood is now thought to be older than the delta. Sample was counted once at a reduced pressure of 125 cm and once mixed with 23.0% of coal gas. Net corrected counting rates: –0.049 ± .041 counts/min and +0.066 ± .031 counts/min respectively. The negative value may be misleading since no background count at similarly reduced pressure was carried out. Ignoring the negative count would give an age of >37,000 yr instead of the quoted value of >39,000 yr.

GSC-25. Inuvik, Northwest Territories **8200 ± 300**

Wood from base of bog deposit, 12-ft thick, exposed on shore of Twin Lakes, 0.3 mi NW of Inuvik, District of Mackenzie (68° 21′ 50″ N Lat, 133° 44′ 10″ W Long). Sample site, at alt ca. 20 ft, has stood above sealevel at least

during accumulation of the bog deposit. Coll. 1960 by J. Ross Mackay, Univ. of British Columbia; subm. by Geog. Branch, Dept. of Mines and Tech. Surveys, Ottawa. *Comment*: on the basis of this date, peat has accumulated at ca. 1.5 ft/1000 yr, assuming that the exposed peat face represents the true thickness of the deposit, and that accumulation at the top of the section has not been retarded appreciably adjacent to the encroaching bank. The site is approximately at the tree line.

GSC-16. Eskimo Lakes, Northwest Territories 7400 ± 200

Wood from 6 in. above base of bog deposit, 7.5-ft thick, exposed in bank of a channel between "fingers" of the Eskimo Lakes, E of the mouth of Mackenzie River, District of Mackenzie (69° 12′ N Lat, 132° 27′ W Long). The deposit overlies organic-rich lake-bottom sand in a tundra area. The sample site, at alt ca. 3 ft, has stood above sealevel at least during accumulation of the deposit. Coll. 1960 by J. Ross Mackay; subm. by Geog. Branch, Dept of Mines and Tech. Surveys, Ottawa. *Comment*: on the basis of this date, peat has accumulated at ca. 1 ft/1000 yr, subject to the assumptions noted above for GSC-25. Sample received no chemical pretreatment.

GSC-10. Kellett River, Banks Island 6940 ± 110

Peat 2-ft below the ground in the wall of a gully 4 mi N of Kellett River, Banks Island, District of Franklin (71° 56′ N Lat, 123° 14′ W Long). Sample is from the upper part of an 8-ft sec. of pond and bog sediments in a shallow depression in the upland adjoining the river valley. Coll.1960 by J. G. Fyles. *Comment*: on the basis of this date and of I(GSC)-197 (9820 ±220, Isotopes II), from base of peat section at the same locality, peat has accumulated at ca. 2 ft/1000 yr.

GSC-12. Northern Banks Island 5730 ± 100

Organic silt from a depth of 8 ft in the wall of a gully 8 mi W of Castel Bay and 8 mi S of N coast of Banks Island, District of Franklin (74° 10′ N Lat, 120° 05′ W Long). Sample from near the base of peaty colluvium, ca. 10-ft thick, flooring a small valley cut into an extensive gravel outwash, alt ca. 200 ft. Coll. 1960 by J. G. Fyles. *Comment*: although definite evidence of recent marine submergence has not been found in this part of Banks Island, the gravel terrace may possibly relate to a shoreline at alt 150 to 200 ft. The date relates to a later time, subsequent to dissection of the terrace. NaOH-leach was omitted from sample pretreatment.

GSC-51. Fosheim Peninsula, Ellesmere Island 28,700 ± 600

Fragments of marine-mollusc shells (including *Hiatella arctica*) from alt 630 ft, 10 mi S of Eureka, Ellesmere Island, District of Franklin (79° 51′ N Lat, 85° 42′ W Long). Sample from the surface, on a hilltop consisting of shale rubble strewn with erratic stones. Within ca. 500 ft of sealevel marine shells, strandlines, and other features record former marine submergence; at higher altitudes (up to 2000 ft or more) thick solid marine-shell fragments and rare thick whole shells are scattered on the surface, but other evidences of submergence are lacking. Coll. 1961 by J. G. Fyles. *Comment*: marine shells

from nearby localities at lower altitudes than this sample lie in the normal postglacial age range (*e.g.* I-264, 8080 ± 160, Isotopes II, coll. 35 mi to NW at alt 510 ft). The much older date of this sample confirms the limit of recent marine submergence at slightly more than 500 ft alt. The shells at higher altitude are inferred to have been carried into their present elevated positions by glacier ice. Another shell sample belonging in this category, coll. 8 mi NW at alt 2000 ft, dated 19,500 ± 1100 (L-548, Lamont VII; Sim, 1961). Although it is possible that both L-548 and GSC-51 provide only minimum age for the high shells, it is tempting to suggest that they originated in Eureka Sound some 30,000 to 20,000 yr ago and were carried to their present positions during a glacial invasion between 20,000 and 10,000 yr ago.

GSC-27. Little Whale River, Hudson Bay 4740 ± 110

Wood from marine clay exposed in a 160-ft river bank ca. 4 mi E of Hudson Bay on the S side of Little Whale River (55° 59′ N Lat, 76° 43′ W Long). Sample from 10 ft above sealevel and 10 ft above base of a 155-ft sec. of clay with sand lenses, overlain by ca. 5 ft of alluvial sand. Coll. 1957 by W. W. Heywood for H. A. Lee, Geol. Survey of Canada. *Comment*: the wood-bearing material is inferred to have accumulated when the sea stood 155 ft (or slightly more) above its present position relative to the land. Date fits well into the middle part a previously drawn uplift/time curve based on nine C^{14}-dated strandlines formed during regression of the Tyrrell Sea (Lee, 1960).

NORTHERN CANADA II

The following dates, and about a dozen companion dates appearing in Isotopes, Inc. date lists I and II, relate to emerged marine shorelines within a zone ca. 800 mi long, trending SE from Banks Island to the W side of Hudson Bay. This zone extends from the outermost moraine built by the Laurentide Ice Sheet during the last glaciation to the Keewatin ice divide (Lee, Craig and Fyles, 1957). If it is assumed that the marine limit at any locality relates to the time of glacial retreat, this group of dates supports the following conclusions (Craig and Fyles, 1960): (1) the last glacial invasion of this part of North America was contemporaneous with the classical Wisconsin glaciation of the Great Lakes region. (2) retreat of the glacial margin within the zone proceeded from W to E and from N to S toward the Keewatin ice divide, as concluded independently from the glacial features, and occurred at about the same time as retreat of the southern margin of the ice sheet.

GSC-48. Richard Collinson Inlet, Victoria Island 11,310 ± 150

Shells of *Hiatella arctica*, coll. ca. 5 mi SW of the head of the E bay of Richard Collinson Inlet, NW Victoria Island, District of Franklin (72° 34′ N Lat, 113° 53′ W Long). Sample from the surface of a silt-floored depression at alt 220 ft, apparently ca. 60 ft below the marine limit. Coll. 1960 by J. G. Fyles. *Comment*: site is ca. 50 mi SE of I(GSC)-18 (12,400 ± 320, Isotopes I), collected about the same distance below the marine limit at the NW extremity of Victoria Island. It has been inferred from glacial geology that the

sea penetrated into the latter area when glacier ice still covered the Richard Collinson Inlet site.

GSC-43. Richard Collinson Inlet, Victoria Island 10,220 ± 150

Marine pelecypod shells from alt 10 to 15 ft at head of E bay of Richard Collinson Inlet, NW Victoria Island, District of Franklin (72° 38′ N Lat, 113° 41′ W Long). Sample from silt lying beneath a few ft of gravel and sand forming a shore terrace at alt 20 ft. Marine limit nearby is at ca. 280 ft. Coll. 1960 by J. G. Fyles. *Comment*: sample is believed to represent a stand of the sea at or only a few ft above the 20-ft shoreline, although it is possible that sealevel was appreciably higher (GSC-19). Assuming that GSC-43 and GSC-48 originated in similar near-shore environments, the land rose relative to the sea, ca. 20 ft per century, between 11,300 and 10,200 yr ago.

GSC-19. Richard Collinson Inlet, Victoria Island 2200 ± 75

Peat from alt ca. 20 ft at head of E bay, Richard Collinson Inlet, NW Victoria Island, District of Franklin (72° 38′ N Lat, 113° 41′ W Long), at same locality as GSC-43. Sample from base of 2-ft peat bed overlying clay at inland edge of 20-ft shore terrace. Coll. 1960 by J. G. Fyles. *Comment*: sample and GSC-43 were dated to bracket the age of the 20-ft shoreline. In view of the large difference between the dates of the two samples, either the peat must be much younger than the shoreline or, less probably, the shells appreciably older.

GSC-49. De Salis Bay, Banks Island 10,920 ± 100

Shells of *Hiatella arctica* collected several hundred ft inland from NE shore of De Salis Bay, 1 mi W of Cape Cardwell, SE Banks Island, District of Franklin (71° 24′ N Lat, 121° 26′ W Long). Shells from surface of gullied clay at alt 50 to 60 ft. Shells and indistinct shorelines were found in the vicinity up to ca. 80 ft. Marine limit not clearly evident but possibly at or slightly above 100 ft. Coll. 1960 by J. G. Fyles. *Comment*: site is ca. 25 mi SE of the outer margin of the outermost (NW) prominent moraine, and probably was invaded by the sea fairly early in glacial retreat. Date based on one weekend count.

GSC-42. Prince Albert Sound, Victoria Island 9710 ± 150

Marine pelecypod shells from alt 450 ft, 40 mi ESE of head of Prince Albert Sound, central Victoria Island, District of Franklin (70° 06′ N Lat, 109° 50′ W Long). Sample consists of fresh shells from centers of clayey frost boils. Marine limit at alt ca. 520 ft. Coll. 1959 by J. G. Fyles. *Comment*: as expected from the pattern of glacial features in the region, this sample is considerably younger than GSC-48 (above), collected about the same distance below the highest marine level some 200 mi NW.

GSC-39. Rae River, Coronation Gulf 9440 ± 120

Marine pelecypod shells from gullied surface of marine clay, alt 320 ft, just N of Rae River 16 mi W of Coppermine, District of Mackenzie (67° 57′ N Lat, 115° 38′ W Long). Site ca. 100 ft below marine limit. Coll. 1959 by

W. L. Davison for B. G. Craig, Geol. Survey of Canada (Craig, 1960, Locality 15). *Comment*: other shell samples from high marine levels in the same area have dates ranging from 8300 to 10,500 yr (I(GSC)-13, 16, 17, 22, and 25, Isotopes I). It has been inferred from the glacial features that the ice-sheet margin retreated from this area at about the time it left the area to the NE represented by GSC-42 (above).

GSC-17. Tree River, Coronation Gulf **1830 ± 80**

Tundra plants dug from an 8-ft sec. of silt in a bank at the mouth of Tree River, Port Epworth, District of Mackenzie (67° 41′ N Lat, 111° 51′ W Long). Sample collected from alt 2 ft from one of several organic layers in the bank. Coll. 1959 by B. G. Craig. *Comment*: sample is believed to have been deposited when sealevel was less than 10 ft above its present position.

Northern Keewatin series

Marine shells found at various alt within an area ca. 100 mi in diam S of Boothia Isthmus, between Pelly Bay and Rasmussen and St. Roch Basins. Marine limit ranges from ca. 600 to ca. 650 ft. Samples are from sites that appear to represent near-sealevel environment. In addition to the following five dates, the series includes dates I(GSC)-179, 212, 213, and 215 in Isotopes, Inc. date list II (this volume). Coll. 1960 by officers of Geol. Survey of Canada "Operation Back River;" interpreted by B. G. Craig (Craig, 1961).

GSC-44. Simpson Lake, East **8870 ± 140**

Pelecypod shells from fine sand in creek bank in esker delta (?), alt 510 ft, 5 mi NE of E end of Simpson Lake, District of Keewatin (68° 30′ N Lat, 91° 05′ W Long). Coll. by B. G. Craig.

GSC-47. Arrowsmith River (560 ft) **8700 ± 120**

Pelecypod shells from ground surface at alt 560 ft on W side of Arrowsmith River 25 mi from Pelly Bay (68° 05′ N Lat, 90° 09′ W Long). Sample from silt in a terrace deposit on the side of a bedrock hill in an area of thick marine sediments. Coll. by M. Tremblay for B. G. Craig.

GSC-46. Murchison River **7790 ± 100**

Pelecypod shells from horizontally bedded fine sand at alt 261 ft, 3 mi from Murchison River on E side of river draining Simpson Lake (68° 29′ N Lat, 92° 09′ W Long). Sample from eroded terrace on the valley wall. Coll. by B. G. Craig. Date based on one weekend count.

GSC-45. Balfour Bay **4460 ± 80**

Pelecypod shells from surface of the uppermost of a series of beaches extending to the top of a drumlin, alt 80 ft, 3 mi E of N end of Balfour Bay (69° 09′ N Lat, 93° 59′ W Long). Coll. by J. D. Aitken for B. G. Craig.

GSC-40. Arrowsmith River (25 ft) **8450 ± 110**

Pelecypod shells from the surface, alt 25 ft, S side of Arrowsmith River 11 mi SW of Pelly Bay (68° 18′ N Lat, 90° 40′ W Long). Shells derived from sand in an area of thick marine sediments. Unusual dark grey to black layers

occur within the shells. These layers, most noticeable after treatment with HCl, were not observed in other shell samples. Coll. by W. W. Heywood for B. G. Craig. *Comment*: date is much older than expected from the low altitude of the site. A second preparation of the sample yielded a date of 8200 ± 150, based on one count. Although the unexpectedly old date may result from contamination, more probably the shells represent deeper-water conditions than anticipated or have been reworked from a higher site.

General comment: above samples, together with I(GSC)-179, 212, 213, and 215 are from a small enough area to be treated as a unit in considerations of glacial retreat and subsequent uplift. As expected from the glacial geology, the oldest dates in the series, applying to sealevels close to the marine limit, are younger than dates of comparable high-level shells cited above from Coronation Gulf and Victoria Island to the W and NW. An alt/time curve for the series (neglecting eustatic sealevel change) indicates that initial rate of emergence was at least 30 ft per century from 8900 to 7800 yr ago. The rate decreased to ca. 14 ft per century from 7800 to 7200 yr ago and then decreased further to ca. 3.5 ft per century from 7200 to 4500 yr ago. Sample I(GSC)-178 (3690 ± 120 from alt 72 ft, Isotopes II) is not included in this series because the locality is outside (W of) the area arbitrarily chosen for the series. Nonetheless, the date fits well into the alt/time curve for the series.

GSC-41. Wager Bay, Northwest Territories **5470 ± 140**

Marine pelecypod shells from fine sand on surface of a terrace, alt 184 ft, on valley wall above a fiord-like lake 6.5 mi N of E end of Ford Lake, near head of Wager Bay (66° 10′ N Lat, 90° 14′ W Long). The terrace may be a remnant of a delta formed when the seashore stood ca. 200 ft below the marine limit (alt ca. 400 ft). Coll. 1960 by M. Tremblay for B. G. Craig. *Comment*: date is considerably younger than I(GSC)-212 (7160 ± 160, Isotopes II) from a comparable altitude in the Northern Keewatin series. Site is just W of the Keewatin ice divide, which is inferred to have been the locus of the last ice-sheet remnant(s) W of Hudson Bay. Marine submergence of the site could not have taken place until glacial retreat in the ice-divide zone permitted the sea to penetrate across the divide from Hudson Bay.

GSC-23. Baker Lake, Northwest Territories **1800 ± 60**

Tundra-plant debris from stream-terrace deposits where Prince River enters Baker Lake, District of Keewatin (64° 18′ N Lat, 95° 46′ W Long). Sample from organic layer, ca. 10 ft above lake, in crossbedded sand in a terrace 25 ft above Baker Lake and ca. 30 ft above sealevel. Coll. 1954 by J. G. Fyles. *Comment*: date is assumed to record the age of the terrace or (less probably) of a slightly higher river-mouth deposit into which the terrace has been cut. The terrace originated either when Baker Lake, and presumably the sea, stood 20-25 ft higher than at present or when the sea flooded the lake basin 25-30 ft above present sealevel. The date fits well into the chronology of postglacial uplift around Hudson Bay compiled by Lee (1960). NaOH-leach omitted from sample pretreatment; coal gas added to sample for counting (51.8% sample, 48.2% coal gas at 2 atm pressure).

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GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES II

W. DYCK and J. G. FYLES*

INTRODUCTION

The accompanying date list includes age determinations completed during the period December 1, 1961 to November 1, 1962. All measurements were made with the 2 L counter described in our first date list (GSC I). Sample preparation, counting procedures, and calculation of dates were as described in GSC I except as outlined below:

a. Base and acid treatments were carried out with 1N HCl and 2% NaOH instead of 2N HCl and 4% NaOH, because the less-concentrated solutions were still strong enough to accomplish the desired purification.

b. The $Mg(ClO_4)_2$ drying columns were removed from the purification train in order to test their effect, if any, on the purity of the gas. Since there was no detectable change in the purity of the gas these columns were left out of the purification line.

c. Ages were calculated using 0.950 of the activity of the N.B.S. oxalic-acid standard as the reference activity and A.D. 1950 as the zero reference year, in line with the recommendations of the editors of *Radiocarbon.*

In general finite ages were calculated only if the sample activity was greater than four standard deviations. Using the 4σ criterion, zero activity in the present system corresponds to an age of >39,000 yr. Thus samples in this date list with ages designated "greater than," yet appreciably below this figure, contained measurable activities which were less than 4σ.

No corrections for barometric-pressure fluctuations have been applied to the measured activities. The observed barometric-pressure fluctuations of ± 1.5 cm, and the barometric-pressure effect of –1.2%/cm Hg would, in the worst possible case, change the calculated age of samples with counting rates near 4σ (i.e. ages of ca. 40,000 yr) by ca. 4%, and by less than 1% for samples with ages of 30,000 yr and younger. Since the ages of all samples with a finite age above 30,000 yr are arbitrarily quoted with a 2σ error, the barometric-pressure effect is well covered.

A 10-pen Esterline-Angus Operation-Event recorder is being used to record continuously the counting rates of the various channels. Signals from specific decatron outputs are fed into univibrator-type circuits which then actuate a relay-driven pen mechanism. The recording consists of blips made by the pens on a chart that moves at constant known speed. Each blip represents 10^n counts where n = 1,2,3, . . . etc., corresponding to the 1st, 2nd, 3rd . . . etc. decatron output which is selected as desired, depending on the counting rate of the particular channel. Thus large counting-rate fluctuations due to electrical and/or atmospheric disturbances can be detected at a glance.

* The introductory part of this paper has been prepared by the first author, who operates the laboratory. The date list has been compiled by the second author from descriptions of samples and interpretations of dates by the various collectors.

The background of the 2 L counter operating at 2 atm has remained constant at 1.4 counts/min for 10 months.

A 5 L copper counter and an all-metal filling line, designed to operate at up to 5 atm, have been constructed. Preliminary tests indicate that background and modern wood counts are 3.0 counts/min and 33 counts/min, respectively, at 1 atm CO_2, and that background increases at ca. 1 count/min/atm.

SAMPLE DESCRIPTIONS

I. GEOLOGICAL SAMPLES

A. Eastern Canada

GSC-56. Grand Falls, New Brunswick **9830 ± 160**
7880 B.C.

Gyttja from borehole in Town of Grand Falls (47° 02.4′ N Lat, 67° 44.5′ W Long), from shelby-tube sample 16 ft to 18 ft below surface (alt 462 ft). The gyttja is underlain successively by Lake Madawaska clay, till of the Grand Falls drift, and gravel. These deposits fill an old buried channel passing through Grand Falls. Coll. 1961 by H. A. Lee.* *Comment*: date is minimum for the Grand Falls drift (other dates: GSC-18, 9820 ± 130, GSC-I; I(GSC)-2, 10,220 ± 350, Isotopes I), and is older than previous dates for Lake Madawaska clay (W-353, 8250 ± 200, USGS IV; L-190B, 8200 ± 300, Lamont II) which crop out N of Grand Falls in the St. John River Valley. In the pollen diagram from this core, prepared by J. Terasmae, the dated sample falls in a zone characterized by a spruce maximum and is assumed to correlate with Deevey's Zone A in Aroostook County, Maine (Deevey, 1951) which Ogden (1959) has correlated with Zone B to the S in Massachusetts and Connecticut. Sample pretreatment did not include the usual NaOH-leach. Sample diluted with dead gas for counting.

GSC-33. Milford Station, Nova Scotia **>33,800**

Wood from gypsum quarry at Dutch Settlement 2 mi SSE of Milford Station (45° 00.5′ N Lat, 63° 25.5′ W Long). Wood from basal part of till 40-ft thick overlying gypsum (*see* Prest in Stockwell, 1957, p. 447). O. L. Hughes (oral communication) relates this till to the lower of two till sheets nearby, both of which are inferred to represent a single Wisconsin glaciation (Hughes, 1957). Coll. 1954 by I. M. Stevenson. *Comment*: wood from the same site has been dated as >18,000 yr by the Nova Scotia Research Foundation using the solid-carbon method (*written communication* J. E. Blanchard to V. K. Prest.

GSC-101. Prince Edward Island, W coast **12,410 ± 170**
10,460 B.C.

Marine shells (*Mya pseudoarenaria*) from sea cliff on W coast of Prince Edward Island 1 mi S of Miminegash (46° 52′ N Lat, 64° 14′ W Long). Shells collected ca. 30 ft above sealevel from bottom 2 ft of a 5-ft bed of clean gray sand with a few red-clay laminae near the base, overlying red clayey till. The

* All persons referred to as collectors or submittors of samples or cited as sources of data are with the Geological Survey of Canada unless otherwise specified.

sand is overlain by 5 ft of poorly sorted gravel. It is believed that the sand accumulated when the shore was ca. 50 ft above its present position and that the poorly sorted gravels were winnowed out of till by waves when the shoreline had dropped below alt 45 ft. The shells relate to a period of major terracing of the W coast following deglaciation of the island, whereas the highest marine features, at alt ca. 80 ft, originated when the island was still partly ice covered. Coll. 1962 by V. K. Prest. *Comment* (V.K.P.) : the date provides evidence that ca. 12,500 yr ago the W coast of Prince Edward Island stood ca. 50 ft lower relative to the sea than at present. Ice retreat from the NW part of the island and initial encroachment of the sea took place somewhat earlier, possibly ca. 13,500 yr ago.

Newfoundland North coast series

GSC-55. Baie Verte River **11,520 ± 180**
9570 B.C.

Marine pelecypod shells (mainly *Macoma calcarea, Mya truncata,* and *Hiatella arctica*) from bank of Baie Verte River, Newfoundland, 3.7 mi above river mouth (49° 54.5′ N Lat, 56° 17′ W Long). Shells from dark-colored silty clay extending 4 ft above river and covered by 10 ft of sand and gravel probably of recent stream origin. The shell-bearing silty clay is 160 ft above sealevel and ca. 60 ft higher than any shells previously reported along this coast. Limit of marine submergence in the vicinity is ca. 200 ft above present sealevel; hence the shells should be little younger than the earliest highest marine features. Coll. 1961 by E. P. Henderson. Date based on one weekend count only.

GSC-75. Middle Arm, Green Bay **11,950 ± 170**
10,000 B.C.

Shells of *Hiatella arctica* and *Mya truncata* from alt 35 to 42 ft in wall of a gully adjacent to N shore of Middle Arm, Green Bay, Newfoundland (49° 42′ N Lat, 56° 06′ W Long), ca. 20 mi SE of GSC-55. The large thick shells are from bouldery, till-like material that probably is glacio-marine. Hence the shells are believed to relate to the initial influx of the sea during glacial retreat. Coll. 1961 by E. P. Henderson.

GSC-87. Southwest Arm, Green Bay **11,880 ± 190**
9930 B.C.

Marine pelecypod-, gastropod-, and barnacle shells and shell fragments from bank of Paddy's Brook, 1 mi upstream from head of Southwest Arm, Green Bay, Newfoundland (49° 35′ N Lat, 56° 12′ W Long). Shells from silty clay at stream level 6 ft below top of bank and 40 ft above sealevel. The clay forms the bottomset beds of a marine delta. The top of the delta at alt 180 ft probably represents the limit of marine submergence in the vicinity, as the delta was largely constructed of outwash from the melting ice. The shells should date the early part of the interval of marine submergence when glacial ice was withdrawing from the area. Coll. 1961 by E. P. Henderson.
General comment: these three dates seem to indicate that the ice withdrew from the N coast of Newfoundland ca. 12,000 yr ago. The dates are considerably older than other dates so far published for Newfoundland (oldest previous

date, for bog-bottom peat from Avalon Peninsula, is I(GSC)-4, 8420 ± 300, Isotopes I).

GSC-89. Anticosti Island, Quebec **12,940 ± 180**
10,990 B.C.

Marine shells (*Hiatella arctica* and *Mya truncata*; identified by F. J. E. Wagner) from cut bank at NE corner of airfield, 4 mi E of Port Menier, western Anticosti Island (49° 50′ 20″ N Lat, 64° 16′ 10″ W Long). Shells from stratified fine gravel and sand with lenses of clay at alt 180 ft (Locality 3, Bolton and Lee, 1960). Marine limit at 250 ft. Coll. 1958 by T. E. Bolton. *Comment*: date applies to an early (but probably not the earliest) stage of post-glacial marine overlap of the island, and is older than dates of comparable materials from Newfoundland to the E (GSC-55, 75, 87, this list) and from the lower part of the St. Lawrence Valley to the W (GSC-61, 63, and 70, this list).

Rivière-du-Loup series, Quebec

The following dates relate to glacial retreat and marine submergences in the lower St. Lawrence basin, involving the following events (Lee, 1962; Lee, *in press*).

1. Deglaciation of the Notre Dame Mountains S of the St. Lawrence near Rivière-du-Loup and encroachment of the sea as far up the St. Lawrence Valley as Trois-Pistoles. GSC-102 relates to these penecontemporaneous events.
2. Later reconstitution of the ice margin in the St. Lawrence basin W of Trois-Pistoles to form the moraine at St. Antonin. GSC-102 and GSC-61 bracket this event.
3. Retreat of ice from the region and progressive uplift of land relative to sea. GSC-102, 63, and 70 relate to uplift "outside" (E of) the moraine at St. Antonin; GSC-61, 69, 68, and 112 relate to uplift behind (W of) the moraine.

GSC-102. Trois-Pistoles **12,720 ± 170**
10,770 B.C.

Shells of *Yoldia arctica* from 23 to 27 ft below ground surface in a highway cut made in 1960, 2 mi E of Trois-Pistoles, Quebec (48° 07.7′ N Lat, 69° 07.9′ W Long). Shells from clay overlain by and regionally interbedded with delta sand. The dated material is part of a marine-deltaic-outwash deposit formed when wastage of the ice sheet permitted the sea to penetrate into this part of the St. Lawrence basin (Lee, *in press*). The delta surface, at alt ca. 550 ft, is believed to mark the local marine limit. Coll. 1962 by H. A. Lee. *Comment*: sample treatment did not include the usual preliminary leaching of the outer 10% of the shells with HCl. Sample diluted with dead gas for counting.

GSC-63. St. Epiphane **11,410 ± 150**
9460 B.C.

Marine pelecypod shells (chiefly *Macoma calcarea, Mya truncata* and *Hiatella arctica*) from 10 to 15 ft below surface in a road cut 2.8 mi N of St. Epiphane, Quebec, near N bank of Rivière Fourche (47° 56.3′ N Lat, 69° 19.2′ W Long). Shells collected at alt 310 ft from lens of gray clay at base of "High Terrace sands" overlying "stony red clay" (Lee, 1962). Date is be-

lieved maximum for the "High Terrace sands" in the vicinity and to represent a marine level at alt 310 ft or slightly higher. Coll. 1961 by H. A. Lee.

GSC-70. L'Isle-Verte, 260 ft **10,600 ± 170**
8650 B.C.

Marine-pelecypod shells (chiefly *Macoma calcarea, Mya truncata*, and *Hiatella arctica* from ca. 25 ft of marine clay (top at alt 260 ft) in road cut 3.8 mi S of L'Isle-Verte, Quebec (47° 57.7′ N Lat, 69° 19.4′ W Long). The shells probably represent the *Macoma calcarea* community (*written communication*, F. J. E. Wagner). Assuming a depth range of 0 to 60 ft for this community, sample represents a marine level at alt between 260 and 320 ft. Coll. 1961 by H. A. Lee. *Comment*: this date and the dates of the two higher samples listed above (GSC-102, GSC-63) comprise a series that decreases in age with decreasing altitude and provides a rough chronology of emergence in the area "outside" the moraine at St. Antonin.

GSC-61. Rivière-du-Loup **10,340 ± 130**
8390 B.C.

Shells of *Hiatella arctica* from gravel pit 0.6 mi SE of railway station, Rivière-du-Loup, Quebec (47° 49.2′ N Lat, 69° 30.8′ W Long). Shells from clay lens within stratified gravels, ca. 7 ft below top of section. Sample believed to be related to a shoreline at or slightly above the top of the section (alt 330 ft). Coll. 1961 by H. A. Lee. *Comment*: this date and the dates for the three lower samples listed below provide a rough chronology of emergence in the area formerly covered by the glacial lobe bordered by the moraine at St. Antonin. As would be expected, GSC-61 is younger than GSC-63 and 70, which appear to relate to about the same marine level "outside" the moraine at St. Antonin. The date for GSC-61 quoted above was determined using our standard procedure for extracting CO_2 from shells. The following additional dates were determined for the outer and inner parts of a second preparation of the sample, after removal of the outer 10% of the shells.

outer fraction (10 to 50% leach)	10,360 ± 240
inner fraction (50 to 100% leach)	10,540 ± 210

GSC-69. L'Isle-Verte, 180 ft **9690 ± 150**
7740 B.C.

Marine-pelecypod shells (chiefly *Hiatella arctica*) from gullied surface of marine clay at alt 180 ft, 2.5 mi SSW of L'Isle-Verte, Quebec (47° 58.1′ N Lat, 69° 19.9′ W Long). Shells were picked from an assemblage representing the *Astarte* zone of the *Macoma calcarea* community (*written communication*, F. J. E. Wagner). Assuming a depth range of 0 to 60 ft for this community, the sample represents a marine level between alt 180 and 240 ft. Date based on one weekend count only. Coll. 1961 by H. A. Lee.

GSC-68. Cacouna **9830 ± 130**
7880 B.C.

Marine-pelecypod shells (chiefly *Macoma calcarea*) from stream-eroded surface, in marine clay at alt 53 ft, ca. 3.5 mi NE of Cacouna, Quebec (45° 57.3′ N Lat, 69° 27.4′ W Long). Shells represent the *Macoma calcarea* com-

munity, possibly the *Astarte* zone (*written communication*, F. J. E. Wagner). Assuming a depth range of 0 to 60 ft for this community, the sample should represent a local sealevel between alt 53 and 115 ft. However, in view of the geology of the locality, the shells may have been reworked from a higher site. Coll. 1961 by H. A. Lee.

GSC-112. Rivière-des-Vases bog **6970 ± 100**
5020 B.C.

Peat collected with a piston sampler at 250 cm depth at bottom of a bog ca. 12 mi NE of Rivière-du-Loup, Quebec (47° 58′ N Lat, 69° 25.5′ W Long). Sample from base of peat overlying sand and gravel at alt ca. 50 ft in an abandoned river channel. Date is minimum for emergence of the site, and hence, for regression of the shore below the 50-ft level. Coll. 1962 by Jaan Terasmae.

GSC-90. Pembroke, Ontario **10,870 ± 130**
8920 B.C.

Marine-pelecypod shells from stratified fine sand and silty clay at alt 450 ft, 15 ft below surface, in a gravel pit ca. 4 mi SE of Pembroke, Ontario (45° 47′ N Lat, 77° 03′ W Long). The shell-bearing deposit occurs as a lens occupying a depression in the top surface of glacio-fluvial gravel and sand, and is overlain in turn by laminated alluvial silty sand and Ottawa River gravel. Coll. 1957 by Jaan Terasmae. *Comment*: date is assumed to record maximum NW extent of the Champlain Sea up the Ottawa River Valley. It supports the earliest date suggested by Terasmae and Hughes (1960a) for the opening of the North Bay outlet. Sample diluted with dead gas for counting.

GSC-77. Thedford, Ontario **3100 ± 80**
1150 B.C.

Wood from cut bank, E side of Decker Creek 1.3 mi N of Thedford, Ontario (43° 11′ N Lat, 81° 51′ W Long). Sample from base of 3-ft layer of alluvial sand overlying shale bedrock and overlain, in succession, by 2 ft of clayey silt with mollusc shells and 3 ft of silty clay with plant remains. The sand inclosing the wood contains pollen suggesting a warm climate. The deposits probably accumulated at or adjacent to the margin of Lake Huron during the Nipissing phase (top of wood-bearing layer 1 ft below average Nipissing level). Coll. 1960 by Aleksis Dreimanis, Univ. of Western Ontario, London. *Comment*: C^{14} age is somewhat younger than expected and may indicate that the deposits accumulated during the later part of the Nipissing phase.

Little Pic River series, Ontario

Wood and shells from gully 150 yd S of E end of bridge over Little Pic River on Trans-Canada Highway around N shore of Lake Superior (48° 47′ N Lat, 86° 37′ W Long). The gully exposes 13 ft of clean sand with abundant *Sphaerium sulcatum* (Lamarck) overlying at least 25 ft of thin bedded clayey silt with disseminated plant materials and two layers that include wood and charred wood. The sloping surface above the gully edge includes another 5 ft of clean sand and, where unmodified by construction work, 1 to 5 ft of windblown sand. Ground alt at E end of bridge 715 ft by altimeter (110 ft above

Lake Superior) although Farrand (1960) records alt of same terrace as 692 ft. The plant-bearing clayey silt is regarded as an estuarine deposit of the ancestral Little Pic River, built into a lake in the Superior basin, at least 90 ft and possibly 110 ft or more above present lake level. The *Sphaerium*-bearing sands are clearly shoreline deposits of a lake 110 ft above present lake level. Coll. 1961 by V. K. Prest.

GSC-82. Little Pic River, upper wood **5920 ± 120** **3970 B.C.**

Wood from upper organic-debris layer in well-stratified clayey silt 80 ft above Lake Superior and 8 ft below base of shell-bearing sand.

GSC-103. Little Pic River, lower wood **5960 ± 110** **4010 B.C.**

Wood from lower organic-debris layer in well-stratified clayey silt 68 ft above Lake Superior and 20 ft below base of shell-bearing sand.

GSC-91. Little Pic River, shells **7060 ± 120** **5110 B.C.**

Shells (*Sphaerium sulcatum*) from central part of 13- to 18-ft mantle of clean sand overlying organic clayey silt, and with surface alt 110 ft above Lake Superior.

General Comment (V.K.P.): study, by J. Terasmae, of woody layers has revealed a pollen assemblage comparable to that of other parts of N Ontario for the period 7000 to 5000 yr B.P. The two wood dates (GSC-82 and 103) are in accord with this interpretation but are older than would be expected if the Little Pic River flats represent the Nipissing-Algoma stage as concluded by Farrand (1960). The discrepancy between the shell and wood dates is regarded as due to recycling of older carbonate during the life of the molluscs.

GSC-83. Attawapiskat River, Ontario (sub-till) >35,800

Wood from W bank of Attawapiskat River, Ontario (52° 36′ N Lat, 86° 02′ W Long). At the sample site, till 16 ft thick is underlain successively by horizontally stratified sand and gravel 7-ft thick and by clay with sand and silt laminae dipping 20° SE. The sparse wood fragments were collected from clay 5 ft below the erosional surface at the base of the sand-gravel unit. Nearby, clay unit is horizontal. Coll. 1961 by H. H. Bostock for V. K. Prest. *Comment:* deposits are assumed to represent the same unit as the better-known sub-till plant-bearing beds along the Albany and Missinaibi Rivers 150 and 250 mi SE. Plant materials from the Missinaibi beds have been assigned various "infinite" C^{14} dates (oldest GrN 1435, >53,000), and the deposits are considered to have accumulated during a post-Sangamon interstadial interval (Terasmae and Hughes, 1960b).

B. Western Canada, general

GSC-74. Piper Ave., Burnaby, British Columbia **12,230 ± 200** **10,280 B.C.**

Shells of *Chlamys* selected from mixed shells in stony marine clay from spoil of a sewer excavation paralleling the Great Northern Railway on the N,

a few hundred feet W of Piper Ave., Burnaby, British Columbia (49° 15′ N Lat, 122° 56′ W Long). The clay is at least 7 ft thick, beneath a 14-ft section of nonmarine sand, peaty sand, peat, and lenses of gravel. Alt of top of clay 39 ft; level of dated shells within the clay is not known. Coll. 1961 by W. H. Mathews, G. E. Rouse, and L. V. Hills; subm. by W. H. Mathews, Univ. of British Columbia, Vancouver. *Comment*: it had been hoped that these shells, coupled with the date of overlying peat would date the emergence of the site. However, in view of other dates from the vicinity, and particularly that of shells from alt 440 ft on nearby Burnaby Mountain (L-391C, 11,900 ± 300, *written communication* J. E. Armstrong), this sample relates to an early phase of marine submergence when the site was still depressed well below sealevel. Date based on one weekend count only.

GSC-64. North Delta, British Columbia **12,460 ± 170**
10,510 B.C.

Shells of *Serpula* and of various marine pelecypods from Linton gravel pit, North Delta, Lower Fraser Valley, British Columbia (49° 08′ N Lat, 122° 55′ W Long). Shells from stony, silty sand overlain by till-like material, glacio-marine stony, clayey silt, and beach gravel. The shell-bearing layer rests on the eroded surface of thick horizontal sand similar to the sub-till Quadra sediments. Coll. 1961 by J. E. Armstrong. *Comment*: the shell-bearing material is interpreted as being glacio-marine, accumulated during wastage of the last (Vashon?) ice sheet. The date is compatible with this interpretation and compares favorably with I(GSC)-248, 12,800 ± 175, Isotopes II. Date based on one weekend count only.

GSC-80. Nanaimo, Vancouver Island **12,420 ± 150**
10,470 B.C.

Marine shells and shell fragments (chiefly *Mya*, *Serripes*, and *Mytilus*) from an excavation at Dept. of Natl. Defense property, Nanaimo, British Columbia (49° 09′ 00″ N Lat, 123° 58′ 10″ W Long). Shells from silty, stony clay, max 10 ft thick, underlain by till and overlain by beach gravel. Site is 354 ft above sealevel and ca. 100 ft below the marine limit. Coll. 1961 by E. C. Halstead. *Comment*: the dated material accumulated during the early part of the interval of postglacial marine submergence when the shore was still less than 100 ft below its earliest highest level. The C^{14} age is a few hundred years younger than expected from other dates from the region, particularly L-391D, wood, 12,150 ± 250, and L-391E, Marine shells, 12,350 ± 250 (Lamont V) from a delta 20 mi NW and only 170 ft above sealevel.

GSC-79. Kamloops, British Columbia **25,200 ± 460**
23,250 B.C.

Fresh water shells (*Margaretifera margaretifera var. falcata, Anodonta nuttalliana*: id. by F. J. E. Wagner) from borrow pit at the base of the S wall of Thompson River Valley ca. 5 mi W of Kamloops, British Columbia (50° 41′ 20″ N Lat, 120° 26′ 30″ W Long). Shells are from clayey silty sand, 35 ft thick, overlain by recent alluvium and underlain by silty clay. Deposits similar to the clayey silty sand and silty clay are exposed beneath till at various places. The shell-bearing deposit accumulated in a lake occupying the Kamloops Lake

basin during an interstadial or interglacial interval prior to the last (classical Wisconsin) glaciation. Coll. 1961 by R. J. Fulton. *Comment*: date agrees with the geologic interpretation (above) based on field evidence. It also supports the tentative inference that the deposits are equivalent to the Quadra sediments in the Strait of Georgia region (see dates below).

C. Interstadial deposits, Georgia Depression, SW British Columbia

The following dates, from the lowlands bordering the Strait of Georgia, British Columbia, apply to various nonglacial, sub-till deposits, including the widespread interstadial Quadra sediments. Dating was undertaken to help distinguish the Quadra and its equivalents from older (and perhaps younger) sub-till nonglacial deposits. Plant materials *known* to belong to the Quadra so far have yielded only finite dates ranging from 24,000 to 36,000 yr (L-221A, L-221B, L-424B, L-424C, L-424E, Lamont V; L-455B, L-502, Lamont VII; GSC-53, 95, 108, 109, this list). Marine shells from the basal part of the Quadra, however, have yielded infinite dates (L-475A, L-475B, Lamont VII). Plant materials that *probably* belong in the basal part of the Quadra at two localities have likewise yielded infinite dates (GSC-81, 94, this list).

GSC-60. East Delta, Lower Fraser Valley **>37,000**

Wood from Kiewet gravel pit, East Delta, Lower Fraser Valley, British Columbia (49° 07′ N Lat, 122° 54′ W Long). Sample from 25-ft section of horizontally stratified silty sand and sand resting unconformably on gravel and overlain by 3 to 5 ft of stony laminated silt, 5 to 10 ft of till, and 5 ft of beach gravel. Coll. 1961 by J. E. Armstrong. *Comment*: see GSC-62.

GSC-62. Knight Road, Lower Fraser Valley **>39,000**

Wood from Knight Road gravel pit, South Westminster, Lower Fraser Valley, British Columbia (49° 10′ N Lat, 122° 55′ W Long). Sample from a 1- to 5-ft layer of clayey silty sand beneath a few feet of till and beach gravel. The wood-bearing material rests on stratified silt containing channel-like bodies of gravel. *Comment*: this sample and GSC-60 are from two of the many small exposures of sub-till stratified deposits along the margin of the Surrey Upland. Such deposits are widely distributed beneath the upland, but little is known of their stratigraphy and none are known to be equivalent to the Quadra sediments. In view of the C^{14} dates, the sampled materials may possibly be older than the Quadra sediments.

GSC-108. Spanish Banks, Point Grey **24,500 ± 500**
22,550 B.C.

Wood from Quadra sand 50 ft above sealevel in sea cliff at Spanish Banks, Point Grey (Vancouver Metropolitan area), British Columbia (49° 17′ N Lat, 123° 13′ W Long). Sample site ca. 300 ft from L-502 (24,400 ± 900, Lamont VII) and at about the same stratigraphic level. Coll. 1962 by J. E. Armstrong. *Comment*: this additional sample from the type section of the Quadra was dated to provide confirmation of the age of the unit, because of uncertainties arising from the infinite date of GSC-81 (this list).

GSC-109. Wreck Beach, Point Grey **25,100 ± 600**
23,150 B.C.

Peat from stratified silt and sand 25 ft above sealevel on sea cliff at Wreck Beach, Point Grey (Vancouver Metropolitan area), British Columbia (49° 16′ N Lat, 123° 15′ W Long). Site ca. 2 mi S of GSC-108. Coll. 1962 by J. E. Armstrong. *Comment*: date supports assignment to the Quadra sediments. Date based on a single count.

GSC-81. Highbury Tunnel, Vancouver **>36,800**

Peat from bore-hole 30-0-9, Highbury St. Sewage Tunnel, Vancouver (City), British Columbia (49° 15′ N Lat, 123° 11′ W Long). Sample from depth between 144 and 147 ft (91 ft above sealevel) at base of sub-till sands believed to belong in the Quadra sediments. Coll. 1962 by J. E. Armstrong. *Comment*: sample was expected to yield a typical Quadra age of ca. 25,000 to 30,000 yr. The inflnite date may possibly be compatible with the inference that the sample belongs at the base of the Quadra (*see* introduction to this group of dates and L-475A, L-475B, Lamont VII). NaOH-leach was omitted from pretreatment of the sample.

GSC-93. Lynn Canyon, North Vancouver **$33,200 \pm {}^{2300}_{1800}$**
31,250 B.C.

Wood from peat bed 2 ft thick near base of Canyon wall, Lynn Creek, North Vancouver, British Columbia (49° 21′ N Lat, 123° 02′ W Long). The peat is underlain by till and lies at the base of more than 150 ft of sand and gravel believed to be equivalent to and younger than the Quadra sediments. Coll. 1960 by J. E. Armstrong. *Comment*: the C^{14} age supports the inference that the sand and gravel unit is in part equivalent to the Quadra sediments. It also suggests correlation with the upper of two sand-gravel units (with basal peat) lying between three till sheets, exposed in a nearby highway cut (*see* I(GSC)-214, 32,200 ± 3300, Isotopes II).

GSC-36. Tupper School, Vancouver **>38,100**

Wood from a peat bed exposed in an excavation at the Sir Charles Tupper School, 23rd and St. George St., Vancouver (City), British Columbia (49° 15′ N Lat, 123° 06′ W Long). Sample from one of several peaty beds within clays and sands ca. 10 ft thick separated from underlying Tertiary sandstone by ca. 1 ft of till and overlain by 5 to 10 ft of Surrey (Vashon) till and Newton glacio-marine deposits. Coll. 1958 by J. E. Armstrong. *Comment*: relation of this sub-till deposit to others in the region remains unknown, but in view of the C^{14} date it may be older than the Quadra sediments.

GSC-58. Upper Campbell, Vancouver Island **25,000 ± 400**
23,050 B.C.

Wood (base of tree 2 in. diam.) ca. 3 ft above the base of a 15-ft cut bank on SE side of logging road immediately above Buttle Lake Road, E side of Upper Campbell Lake, Vancouver Island, British Columbia, 1000 ft NE of Berry Creek and alt ca. 780 ft (49° 56′ 50″ N Lat, 125° 35′ 50″ W Long). Sample from a layer of sticks in the bottom few inches of a 7-ft section of in-

distinctly laminated silt, clay, and fine sand containing peaty partings. Beneath the wood layer is 3-to-6 in. of peaty silt resting on and penetrating downward into angular gravel which directly overlies bedrock at one end of the exposure. This sequence of deposits forms an isolated pocket, covered by slope debris, at the bottom of the steep wall of the U-shaped valley. The deposits appear to belong at the base of several hundred feet of horizontal sands and silts capped by till in the re-entrant in the valley wall occupied by Berry Creek. These and other isolated bodies of similar materials in the valley and on the lowland to the NE are believed to be remnants of formerly extensive fluvial and lacustrine deposits that have survived glaciation. The C^{14} date supports correlation with the Quadra sediments. Coll. 1958 by J. G. Fyles.

GSC-96. Buttle Lake, Vancouver Island **25,190 ± 470**
23,240 B.C.

Wood from a small tree (*Abies*) exposed in a road cut, E bank of Campbell River at upstream end of U-bend in river 1 mi N of Buttle Lake dam, Vancouver Island, British Columbia (49° 51′ 05″ N Lat, 125° 37′ 20″ W Long); collected from 1.5 ft of laminated silt with organic layers, overlain by ca. 20 ft of till and gravel. The plant-bearing material is separated from the steep bedrock wall of the U-shaped valley by a few inches of angular gravel resembling sliderock. The deposit is believed to be a remnant of the same stratigraphic unit as GSC-58 (*see* above) collected ca. 7 mi N in the same valley. Date supports correlation with the Quadra sediments. Coll. 1958 by J. G. Fyles.

Willemar Bluff series, Vancouver Island

Wood from two levels within the sand unit of the Quadra sediments on the sea cliff at Willemar Bluff 1.5 mi E of Comox, Vancouver Island, British Columbia (49° 40′ 10″ N Lat, 124° 53′ 50″ W Long). Coll. 1957 by J. G. Fyles.

GSC-53. Willemar Bluff, upper wood **26,100 ± 400**
24,150 B.C.

Water-worn fragments of wood from driftwood lens in sand 118 ft above high-tide level.

GSC-95. Willemar Bluff, lower wood **28,800 ± 740**
26,850 B.C.

Flattened wood up to 0.5 in. diameter from 3-in. bed of silty peat 70 ft above high tide.

General comment: these two dates are in correct stratigraphic sequence in relation to each other and also in relation to L-424B, L-424C, and L-424E (30,200 ± 1300, 29,300 ± 1400, 30,000 ± 1200, respectively; Lamont V) for wood from the thin silt-gravel unit of the Quadra sediments beneath the sand unit on Denman Island 5 mi to the SE (Fyles, 1960). Despite overlap of the age range of the three Lamont dates with that of GSC-95, the correct stratigraphic arrangement of the dates is taken as evidence supporting the validity of the finite C^{14} ages assigned to plant materials from the sand unit and the silt-gravel unit of the Quadra (*see* discussion of Quadra beds series,

Lamont V). The sequence of dates also points up the disparity between these finite dates and the infinite date assigned to shells from the immediately underlying marine stony clay (L-475A, Lamont VII; *see* also GSC-94, this list).

GSC-78. Wilfred Creek, Vancouver Island **>37,600**

Dense peat from a fresh landslide scar on the wooded NW wall of Wilfred Creek valley, 1.3 mi upstream from the E and N Railway, near Fanny Bay, Vancouver Island, British Columbia (49° 28′ 25″ N Lat, 124° 50′ 00″ W Long). The peat layer, 0.5 in. thick, lies within 20 ft of laminated silt, sand, and pebble gravel containing oxidized plant remains. These materials are underlain by thick bouldery gravel and overlain by 150 ft of pebble gravel and sand capped by a few feet of till. These sub-till deposits, which underlie an area 5 mi long and up to 2 mi wide, differ somewhat in lithology from the Quadra sediments. From geologic evidence, they may be either a facies variant of the Quadra or an entirely different unit; on the basis of this date they may be older than the Quadra. Coll. 1956 by J. G. Fyles.

GSC-99. Chef Creek, Vancouver Island **>37,900**

Wood from cut bank, S side of Island Highway 0.25 mi E of Chef Creek, near Deep Bay, Vancouver Island, British Columbia (49° 27′ N Lat, 124° 45′ W Long). Sample from an inter-till section 10 ft thick in which fine sand and silt containing wood and mats of plant detritus grade laterally into medium to coarse sand and into shell-bearing marine clay beneath the sand. These deposits are inferred to form the base of the Quadra sediments at this locality (Fyles, 1963, p. 26, 27) and have yielded abundant pollen suggesting forest comparable to that growing today in the wetter parts of Vancouver Island (Fyles, 1963, p. 28). Coll. 1951 by J. G. Fyles. *Comment*: this date raises the same problem regarding the age range of the Quadra interval as other samples such as GSC-81 and GSC-94 (this list). In spite of the infinite date, the collector still tentatively assigns the deposits to the Quadra sediments, but admits the possibility that they are distinct from and older than the Quadra.

GSC-84. Cordova Bay, Vancouver Island **22,600 ± 300**
20,650 B.C.

Plant fibers concentrated from organic silt 40 ft above the beach on a sea cliff, SE part of Cordova Bay, near Victoria, Vancouver Island, British Columbia (48° 29′ 40″ N Lat, 123° 19′ 10″ W Long). The sampled bed lies within a 50-ft section of organic silt and fine sand overlain by 80 ft of sand and underlain by thin gravel and marine stony silt. These nonglacial strata lie beneath the surface (Vashon) till and belong to a widespread interstadial unit similar in lithology and occurrence to the Quadra sediments. At the E end of Cordova Bay, till beneath these deposits is underlain by a second succession of rather similar nonglacial deposits overlying a still older till. Coll. 1958 by J. G. Fyles. *Comment*: date suggests correlation of the widespread upper interstadial unit on SW Vancouver Island with the Quadra sediments. This is the youngest date so far assigned to sub-till deposits in the region. *See* also comments concerning GSC-94, below.

GSC-59. Sidney Island **23,920 ± 420**
21,970 B.C.

Wood from the base of a wave-cut cliff on the E side of Sidney Island, Haro Strait, British Columbia (48° 38′ 40″ N Lat, 123° 19′ 40″ W Long), a few tens of feet S of base of spit at N end of island. The small flattened pieces of wood were collected from a 1-ft bed of peaty silt in a shallow pit at the inshore margin of the beach. The peaty bed is underlain by fine sand and overlain by 10 ft of sand capped by till. The same sub-till deposits are exposed in many places (thickness up to 80 ft) along the E shore of the island for 2 mi S of the sample site. Coll. 1958 by J. G. Fyles. *Comment*: the sub-till deposits to which this date applies are characteristic of the widespread sandy upper interstadial deposits of the SW Vancouver Island region. The date supports correlation of this unit with the Quadra sediments (*see* GSC-84).

GSC-94. Cowichan Head, Vancouver Island **>38,400**

Wood collected 35 ft above the beach on a sea cliff at Cowichan Head, Saanich Peninsula, Vancouver Island, British Columbia (48° 34′ N Lat, 123° 22′ W Long). Sample from a pocket of driftwood within 7 ft of pebbly fine silty sand containing marine shells. This material grades upward into sands and sandy gravels 80 ft thick capped by till, and is underlain by ca. 10 ft of stony marine silt and clay. This sequence of strata beneath till is believed to be equivalent to the upper inter-till unit at Cordova Bay ca. 5 mi to the S (*see* GSC-84, above). Coll. 1958 by J. G. Fyles. *Comment*: wood from stony marine clay at Cowichan Head at a slightly lower level than this sample has been dated as >42,000 (L-514C, Lamont VII). Shells from the stony marine clay have yielded an age of 35,000 ± 1600 (L-514D, Lamont VII) but the author of the Lamont date list suggests that the shells are contaminated. If the sands above the wood- and shell-bearing deposits belong to the same stratigraphic unit as GSC-84 and 59, as maintained by the collector, then the wood- and shell-bearing deposits are much older than the overlying sands. This age difference is analagous to that between comparable units of the Quadra sediments (*see* L-475A, L-475B, Lamont VII and various entries in this list above).

D. Northern Canada

Hunker Creek series, Yukon

Wood from frozen silty peat in a fresh cut-bank exposure in right bank of Hunker Creek, at the mouth of Last Chance Creek, Klondike Dist., Yukon (64° 01′ N Lat, 139° 06′ W Long). Samples were collected from a 20-ft bed of woody, silty peat underlain by 6 ft of silt containing plant detritus down to the creek. Sand and gravel seams occur in the base of the peat unit. Coll. 1961 by Jaan Terasmae and O. L. Hughes.

GSC-57. Hunker Creek **8660 ± 140**
6710 B.C.

Wood from woody silty peat unit at depth 16 ft. Pollen is poorly preserved; vegetation was similar to the present Boreal forest.

GSC-73. Hunker Creek **9520 ± 130**
7570 B.C.

Wood from base of woody silty peat unit at a depth of 20 ft. *General comment* (O.L.H.): the change from uniform silt (lower part of this section) to woody silty peat containing sand and gravel seams (upper part of this section) represents a significant change in sedimentation. The age of GSC-73, immediately above this break, is almost identical with the 9510 ± 220 yr age (I(GSC)-196, Isotopes II) obtained for organic silt underlain by silty gravel with mammal bones, and capped by woody peat, from Fant and Norbeck placer pit 4.5 mi upstream on Hunker Creek. Silt in the lowermost 6 ft of the present section is tentatively correlated with silt that lies beneath the bone-bearing gravel at Fant and Norbeck placer pit, and that has yielded wood dated at >35,000, (I(GSC)-181, Isotopes II).

GSC-66. Hay Ranch Bog, Yukon **280 ± 120**
A.D. 1670

Peat, 12 in. below surface, in an extensive muskeg along Klondike River ca. 15 mi E of Dawson, Yukon (64° 03′ N Lat, 139° 00′ W Long). Exposure in a highway borrow pit shows alluvial gravel at base, overlain by thin sand layer (2 to 5 in.) and 6 to 8 in. of decomposed woody peat and 12 in. of fresh *Sphagnum* peat. Coll. 1961 by Jaan Terasmae. *Comment*: the sudden change in the peat sequence is accompanied by an increase of black spruce, pine, and ericaceous pollen and *Sphagnum* spores possibly reflecting climatic change. Sample was treated with cold (rather than hot) NaOH and HCl.

Hart Lake marl series, Yukon

GSC-67. Carbonate fraction **12,900 ± 150**
10,950 B.C.

GSC-67-2. Organic residue **12,120 ± 140**
10,170 B.C.

Marl from ca. 6 ft below original surface, exposed on the face of a frost-heaved block in an area of palsa mounds, NW end of Hart Lake, Yukon (64° 37′ N Lat, 135° 10′ W Long). The marl is overlain by 2 to 12 in. of peat. Hart Lake, in which the marl was deposited, is impounded by a moraine ridge at its NW end. The age is minimum for retreat of a valley glacier from the moraine. Coll. 1961, by Peter Vernon; subm. by O. L. Hughes. *Comment* (O.L.H.): the age is compatible with approximate correlation of the moraine with late Wisconsin moraines of the region, but does not rule out correlation with considerably older moraines of the same region. Carbonate rocks are abundant in the area; the greater apparent age of the inorganic fraction may be attributed to hard water effect.

GSC-97. Peel River, Yukon **8780 ± 160**
6830 B.C.

Wood from 6.5 ft below surface in the backwall of a flow slide, S bank of Peel River 3.5 mi downstream from mouth of Wind River, Bonnet Plume Basin, Yukon (65° 52′ N Lat, 135° 08′ W Long). Peel River at this point is intrenched through 230 ft of Pleistocene and 135 ft of Tertiary sediments. The

Pleistocene stratigraphy, typical of that exposed along lower Wind and Bonnet Plume Rivers, and Peel River between the mouths of the former, consists from the bottom up of gravel, glacio-lacustrine clay, till, and glacio-lacustrine clay, capped by woody silt and peat. Coll. 1962 by O. L. Hughes. *Comment*: the age of the sample, from near the base of woody silt and peat at the top of the section, is minimum for drainage of a glacial lake which discharged northward via Eagle River during retreat of a lobe of Laurentide ice which earlier had pushed westward at least to 136° 20′ W Long. Drainage may have occurred considerably before burial of the wood. Date based on one weekend count only.

GSC-54. Mackenzie River Delta **6900 ± 110**
4950 B.C.

Wood from depth 125.5 ft in bore-hole MD2, Natl. Res. Council permafrost borings 5 mi SW of Inuvik, Dist. of Mackenzie, Northwest Territories (68° 18′ N Lat, 133° 50′ W Long), on the delta plain of Mackenzie River. The borings encountered (top to bottom) 100 ft of thinly stratified sandy silt with layers of woody plant material throughout, 80 ft of sand with plant layers (dated sample), spaced at irregular intervals throughout, and 60 ft of dense clay with no visible organic remains and with stones in the lowermost few feet. Microorganisms from various woody layers represent fresh water rather than marine conditions. Coll. 1961 by G. H. Johnston, Div. of Building Res., Natl. Res. Council, Ottawa, Canada. *Comment*: evidently the plant-bearing esturaine-deltaic sand and silt began to accumulate several thousand years after retreat of the last (classical Wisconsin?) Laurentide Ice Sheet from the site, which is close to ice-sheet limit. NaOH-leach was omitted from pretreatment of the sample.

GSC-34. Nicholson Peninsula **>35,200**

Wood collected 20 ft below top of 120-ft sea cliff at N end of Nicholson Peninsula, Dist. of Mackenzie, Northwest Territories (69° 56′ N Lat, 128° 55′ W Long). Sample from deformed sand containing numerous flattened logs up to 5 in. in diam. Shells of *Yoldia arctica* (id. by F. J. E. Wagner), are present in underlying clay, and fragments of mammoth (?) tusk apparently washed out of the cliff are present on the beach. The wood-bearing strata are believed to have been deformed by glacial ice thrust (Mackay, 1956) and therefore to be older than the last glacial invasion of the region. Coll. 1960 by J. Ross Mackay, Univ. of British Columbia; subm. by the Geog. Br., Dept. of Mines and Tech. Surveys, Ottawa, Canada.

GSC-32. Arrowsmith River (560 ft) Peat **4530 ± 120**
2580 B.C.

Woody plant material at alt 560 ft on W side of Arrowsmith River 25 mi from Pelly Bay (68° 05′ N Lat, 90° 09′ W Long). Sample from bottom of section of several feet of peat lying on marine silt. Coll. 1960 by M. Tremblay for B. G. Craig. *Comment* (B.G.C.): this sample and shell sample GSC-47 (8700 ± 120, GSC I) were dated to bracket time of emergence of the site. However, date of this sample suggests emergence long before accumulation of the peat. Sample treated with cold (rather than hot) NaOH and HCl.

GSC-65. White Point, Ellesmere Island **$38{,}600 \pm {}^{3700}_{2600}$**
36,650 B.C.

Marine pelecypod (mostly *Hiatella arctica*) shells and fragments collected 2 mi inland from Nansen Sound 5 mi S of White Point, Ellesmere Island, Northwest Territories (81° 07′ N Lat, 90° 07′ W Long). Shells from slumped bank of modern stream, alt ca. 400 ft, ca. 150 ft above the highest clearly defined marine features. The shells occur in stratified gravel, sand, and silt containing thin organic layers. On the basis of poor exposures, the shell-bearing material is inferred to underlie till. Coll. 1961 by J. G. Fyles. *Comment*: date is based on three counts. As the shells were collected from the ground surface where they could readily be contaminated with the minute amount of modern carbon required to give them the measured activity, the date should probably be regarded as minimum.

GSC-105. Oobloyah Bay, Ellesmere Island **4190 ± 130**
2240 B.C.

Peat collected a few hundred feet from the ice cliff at the W side of a piedmont glacier tongue blocking the head of a valley 10 mi E of the head of Oobloyah Bay, Ellesmere Island, Northwest Territories (80° 54′ N Lat, 82° 17′ W Long). Sample from the bottom of a stream bank cut into peat that has accumulated on the valley floor upstream from a cross-valley moraine 1/3 mi W of the present ice cliff. The sample was collected ca. 6 ft below ground but the true stratigraphic depth is probably less than this figure. The base of the peat was not exposed at the sample site but elsewhere the peat rests on gravel at depths of 1 to 3 ft. Coll. 1961 by J. G. Fyles. *Comment*: date is minimum for the moraine. Moreover, the piedmont-glacier lobe is now as extensive as, and probably more extensive than at any time during the last 4000 yr. Sample mixed with dead gas for counting. Date based on one count.

II. ARCHAEOLOGICAL SAMPLES

GSC-85. Pic River Site, Ontario **1000 ± 80**
A.D. 950

Charcoal from Pic River site, W bank of mouth of Pic River, N shore of Lake Superior, Ontario (48° 36′ N Lat, 86° 17′ W Long). Sample from Stratum 3, Sq OEIN2, depth 9 in. It relates to a pure component of the Blackduck Focus which played a major role in the Late Woodland culture history of N Minnesota, NW Ontario, and SE Manitoba. Coll. 1960 by J. N. Emerson; subm. by J. V. Wright, Nat. Mus. of Canada, Ottawa.

GSC-86. Malcolm Site, Ontario **3850 ± 90**
1900 B.C.

Charcoal from the Malcolm site (Dailey and Wright, 1955) 3 mi W of Cornwall, Ontario, in Lot 23, Concesion 1, Cornwall Twp., Stormont Co. (45° 01′ N Lat, 74° 49′ W Long). Sample from Pit 11, Trench 1, Sector 15, depth 22 to 25 in. below surface. Coll. 1954 by J. V. Wright. *Comment*: charcoal came from one of seven large pits devoid of cultural material. The date indi-

cates pits are much older than the Point Peninsula 4 Focus material mantling the site and suggests they belong to the Archaic period, even though diagnostic Archaic traits were lacking.

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